Green Fingertips
Making Greener Labs a Reality

Green Fingertips - Case Studies

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Every meaningful environmental shift begins with real stories of people, communities, and organisations choosing to act differently. The following case studies highlight the practical steps, creative solutions, and measurable impact achieved by those who have embraced greener ways of living and working. They serve not only as proof that sustainable change is possible, but as inspiration for what can happen when commitment meets innovation. These examples demonstrate that environmental responsibility isn't a distant ideal; it's a series of achievable actions that collectively shape a healthier future. As you explore each case, consider how these insights might spark new ideas, partnerships, or opportunities within your own sustainability journey.

Case Study 1: Environmental Optimisation of Scientific Methods

Mark is an analyst in the water industry and is required to design a method to detect metaldehyde in water and prepare an analytical study. He uses a GC-MS technique, which involves extracting metaldehyde from water using a pre-conditioned solid-phase extraction (SPE) polymer cartridge. The cartridge is then eluted with organic solvents and the extract is subsequently analysed by GC-MS. He wrote the following summary for the execution of this work:

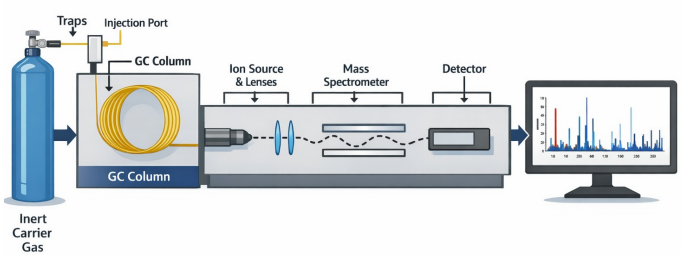

Fig. 1 Schematic of GC-MS

1.1 Action summary

Wash the SPE cartridge with water and trimethylpentane using a power-generated vacuum system. Dry the cartridge under vacuum for 40 minutes. Condition the SPE cartridge with an acetone–ethyl acetate mixture, followed by water, and discard all eluents. Introduce the pre-weighed water samples to the SPE column and allow them to pass through under gravity to retain metaldehyde on the cartridge. Wash the cartridge with aqueous methanol, and dry the cartridge under vacuum for 1 hour. Elute trapped metaldehyde in cartridge with an acetone–ethyl acetate mixture followed by trimethylpentane, and collect the extract. The final extract volume will be approximately 3 mL, which is then concentrated to 200 μL for GC-MS analysis.

1.2 Environmental Impact

The experimental procedure for detecting metaldehyde in water involves several environmental impacts that must be carefully considered and mitigated. The method relies heavily on organic solvents, including acetone, ethyl acetate, trimethylpentane, and methanol. These solvents are volatile, flammable, and capable of contributing to air emissions if not handled within appropriate containment systems. Improper disposal of solvent waste poses risks to soil and aquatic environments, as these chemicals can persist and cause toxicity if released without controlled treatment.

The solid-phase extraction (SPE) process generates additional waste streams, including aqueous eluents and solvent mixtures that require regulated disposal. The use of single-use plastic SPE cartridges contributes to non-recyclable laboratory waste, adding to the overall environmental burden associated with consumables. Furthermore, the procedure involves extended vacuum drying and solvent-evaporation steps, which increase energy consumption and indirectly contribute to environmental impact through higher resource use.

To minimise the ecological footprint of the method, strict waste-segregation practices, solvent recovery where feasible, and adherence to hazardous-waste disposal regulations are essential.

1.2.1 Recommendations

To enhance the sustainability and overall efficiency of the metaldehyde analysis method, several improvements are recommended. If the organisation continues to employ the current SPE–GC-MS workflow, opportunities to reduce solvent consumption should be prioritised. This may include optimising SPE condi-

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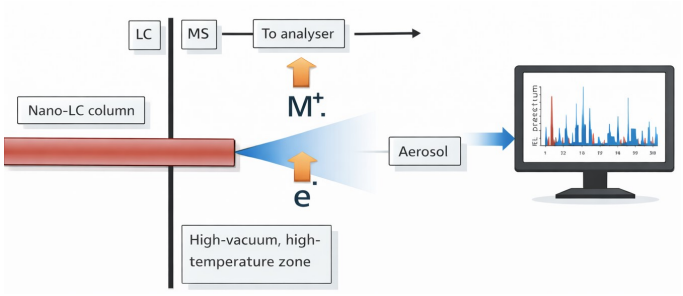

Fig. 2 Schematic of LC-MS interface

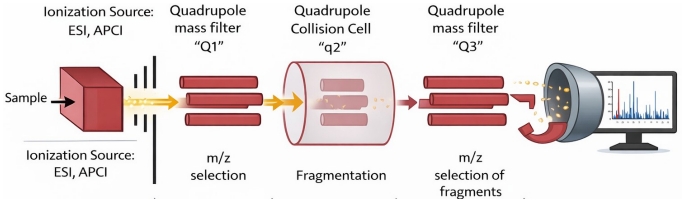

Fig. 3 Schematic of LC-QQQ

tioning and elution volumes, adopting micro-extraction formats, or implementing solvent-efficient evaporation systems. Reducing solvent use not only lowers environmental impact but also decreases operational costs.

Transitioning to more sustainable consumables should also be considered. The use of recyclable or biodegradable SPE cartridges, or reusable extraction formats where analytically appropriate, can significantly reduce plastic waste. In addition, implementing solvent-recovery systems for acetone, ethyl acetate, and methanol can help reclaim usable solvent for non-critical applications, thereby reducing hazardous-waste output.

Energy consumption can be minimised by using energy-efficient vacuum pumps, reducing unnecessary drying times, and processing samples in batches to avoid repeated equipment start-ups. Ensuring that all solvent handling is carried out in closed systems or fume hoods will further reduce atmospheric emissions and improve laboratory safety.

While improvements to the existing method are possible, adopting a more environmentally friendly direct-analysis approach using LC-MS or LC-QQQ is strongly recommended. This technique eliminates the need for SPE cartridges and significantly reduces solvent use. If samples contain particulate matter, simple filtration is sufficient; however, filtration is unnecessary when samples are visually clear. Transitioning to LC-MS would therefore reduce chemical consumption, energy use, and waste generation while maintaining analytical performance.

Overall, a combination of solvent reduction, sustainable consumables, improved energy efficiency, and consideration of alternative analytical techniques will support continuous improvement and help minimise the environmental footprint of the analytical workflow.

Case Study 2: Legacy Laboratory Practices and Barriers to Process Improvement

David is a senior scientist in the chocolate and food industry with 35 years of continuous service in the same organisation. One of his responsibilities is conducting routine viscosity analysis on solid chocolate samples to monitor manufacturing operations and product quality. Samples are delivered every other Monday, and testing is scheduled for Friday morning.

The viscosity analysis is performed using a viscometer maintained at 40°C (±0.1°C). Before analysis, chocolate samples must be heated at 50°C for a minimum of one hour and homogenised to ensure they are fully liquefied.

2.1 Current Practice

To ensure samples are ready for testing, David places them in an oven immediately upon receipt on Monday and keeps them there until shortly before analysis on Friday. The oven remains switched on continuously, even when empty. Instrument suitability is checked using a single control sample before each testing session, and results are issued with an associated error margin.

After completing the analysis, David prepares a printed report, collects wet signatures from laboratory personnel and plant engineers, and then scans the signed document for digital storage. As the longest-serving member of the team, David is also responsible for training new staff on this procedure.

2.2 Issue Raised

Meera, a newly hired staff member, questioned several aspects of the established workflow during her training. Specifically, she asked: - Whether there was any technical or health-and-safety justification for keeping the oven running continuously. - Why chocolate samples were stored in the oven for nearly four days when the method only required a minimum of one hour of heating. - Why printed reports and wet signatures were still required when digital approval processes could achieve the same outcome more efficiently.

Meera did not receive a scientific or procedural rationale for these practices. Instead, she was told that the process had been followed for 35 years and that she was not in a position to challenge or change existing laboratory procedures.

2.3 Environmental Impact

The current viscosity testing workflow presents several environmental concerns linked to energy use, resource consumption, and unnecessary waste generation. The practice of keeping the oven switched on continuously from Monday to Friday regardless of whether samples are present results in significant and avoidable energy consumption. This contributes to increased carbon emissions and higher operational costs without offering any technical benefit, as the method requires only one hour of heating prior to analysis.

Storing chocolate samples in the oven for several days also leads to inefficient use of equipment and energy. The prolonged heating period does not enhance sample quality or analytical

accuracy, yet it increases the laboratory's overall environmental footprint. Additionally, the continued reliance on printed reports and wet signatures generates unnecessary paper waste and requires additional energy for printing and scanning, despite the availability of secure digital alternatives. These practices highlight a broader issue of outdated procedures that do not align with modern sustainability expectations. Addressing these inefficiencies would reduce energy consumption, minimise waste, and support the organisation's commitment to environmentally responsible operations.

2.4 Recommendations

Several improvements can be made to reduce the environmental impact of the current viscosity-testing workflow and modernise laboratory practices. The most immediate action is to discontinue the practice of keeping the oven switched on continuously. The oven should only be operated when samples require heating, as the method specifies a minimum of one hour at 50°C. Implementing a controlled heating schedule or using timers would significantly reduce unnecessary energy consumption.

The sample-handling process should also be reviewed to ensure that chocolate is only heated for the required duration. This change would reduce energy use, prevent equipment wear, and align the procedure with documented analytical requirements.

In addition, the laboratory should transition from printed reports and wet signatures to a secure digital approval system. Digital workflows reduce paper waste, eliminate the need for scanning, and streamline communication between departments.

Finally, the organisation should encourage a culture of continuous improvement by allowing staff at all levels to question existing practices and propose evidence-based changes. Establishing a formal review process for legacy procedures would help ensure that laboratory methods remain efficient, sustainable, and scientifically justified.

Case Study 3: Regulatory-Aligned Method Refinements Delivering Enhanced Sustainability and Analytical Efficiency

To support the release of clinical trial materials within the framework of New Product Introduction, CDMO in a pharmaceutical sector required validation of an analytical method for the identification, quantification, analysis of related substances and assay of the CRT-008 drug product. CRT-008 has been utilised in the industry for more than 30 years, and the analytical method was developed through minor adaptations of an existing pharmacopeial procedure. Beyond confirming the method's suitability for generating accurate and precise results, this validation exercise was specifically designed to reduce result turnaround times in response to increased customer demand and to minimise environmental impact. Accordingly, all validation activities were conducted in strict adherence to current ICH guidelines, with the company's established Standard Operating Procedure (SOP) serving as a reference document. Furthermore, legacy workflows were revised to modernise processes such as sample and standard preparation, instrument suitability checks, establishment of system suitability parameters, and results reporting. The following table presents a comparison of previous and revised practices implemented during this validation activity in processes such as sample and standard preparation, instrument suitability assessments, definition of system suitability criteria, and reporting of analytical results.

3.1 Implementation

Comparison of current and revised practices aligned with ICH guidelines are detailed in Table 1 and Table 2 .

3.2 Environmental Impact

The implementation of the revised analytical practices has resulted in a measurable reduction in environmental impact while maintaining full compliance with ICH principles and method validation requirements. Removal of the routine sample-filtration step supported by solubility data and comparative chromatographic assessments has eliminated the unnecessary use of single-use plastic filters and reduced instrument run time associated with filtration-dependent workflows. Extending the stability of standards and sample solutions through refrigerated storage has further reduced the frequency of solution preparation, thereby lowering solvent consumption, minimising chemical waste, and decreasing the use of consumables. The adoption of pre-prepared, stability-verified sensitivity standards has enabled same-day system suitability and sample analysis, reducing prolonged instrument conditioning and avoiding repeated preparation of standards, which in turn decreases energy usage and solvent waste. Reclassifying the column platelet count as an informational parameter has prevented unnecessary column rejection and repeat analyses, supporting more efficient column utilisation. Additionally, optimisation of the linearity assessment from forty injections to ten has significantly reduced solvent usage, energy demand, and instrument wear. Collectively, these scientifically justified modifications contribute to a more sustainable analytical process by reducing waste generation, lowering resource consumption, and improving overall operational efficiency without compromising data integrity or regulatory compliance.

Case study 4: Fermentation Lab: Transforming Organic Waste into Sustainable Solutions

Across the region, local food manufacturers and agricultural processors were producing thousands of tonnes of organic by-products annually. The majority of this material was either sent to landfill or hauled considerable distances for disposal, leading to increased greenhouse gas emissions and substantial waste management expenses. Recognising the potential in this discarded resource, a mid-sized biotechnology facility specialising in microbial fermentation identified an opportunity to convert organic waste into valuable, low-carbon products.

4.1 Implementation

The laboratory devised an innovative fermentation platform utilising naturally occurring microbes to break down organic

Current Practice	Revised practice implemented following ICH guidelines with the scientific rationale
A thorough study was conducted to determine the most appropriate filter for sample preparation. The study was structured to evaluate the differences between filtered and unfiltered samples, as well as the diluent, utilising a range of filter types.	Sample filtration is required only when visible particulate matter is present. Filtration may also be used to extend the lifespan of shorter analytical columns, particularly UPLC columns, for which filtration is generally recommended. However, there is no ICH requirement mandating sample filtration. The product is fully soluble in the selected diluent, and no solubility issues were observed. Furthermore, a simple comparative assessment demonstrated that chromatograms obtained from filtered and unfiltered samples showed no significant differences. Therefore, the filtration step was removed, resulting in substantial savings in analytical resources, including reduced instrument run time, decreased use of single-use plastic filters, and faster overall result turnaround.
The stability of standards and sample solutions was evaluated over a period of seven days under ambient storage conditions.	Restricting the stability assessment of standards and sample solutions to a seven-day period at ambient temperature did not yield notable environmental advantages, as this approach required the frequent preparation of fresh solutions for each analytical run, thereby increasing resource consumption. To address this, the stability of both samples and standards was subsequently evaluated under refrigerated conditions, utilising a single batch preparation that was monitored continuously for stability, including post-validation. Standard solutions were further categorised into stock standard and working standard preparations, with the objective of establishing an extended stability period for the stock standard. In cases where prolonged stability for the working standard could not be demonstrated, efforts were concentrated on confirming the longer-term stability of the stock standard.
To assess the machines suitability an extensive run of system suitability standards needs to be run prior to analysis. This requires fresh preparation of standards for each analytical run. The system requires to condition prior to running with mobile phases and appropriate diluent injections. Due to the assemnt of the system suitability run needs approximately 2 days generally until the 3rd day the samples can not inject to the system for analysis.	It is recommended that sensitivity standards, such as those corresponding to the limits of detection (LOD) and quantification (LOQ), be prepared in advance and stored under refrigerated conditions. The stability of these standards should be confirmed through the previously described stability assessment protocol. Upon verification of their stability, a single test injection of the pre-prepared sensitivity standard may be performed. If this injection meets established system suitability criteria, both the conventional system suitability standards and sample analyses may proceed on the same day. This approach minimises resource consumption and reduces environmental impact by limiting the need for repeated standard preparation and excessive instrument usage.
For the assessment of column sensitivity, platelet count shall be designated as the sole evaluative parameter. A specific numerical threshold for platelet count will be established, and only columns meeting or exceeding this value will be considered suitable for analysis. Should a column fail to achieve the predetermined platelet count, it will be excluded from use irrespective of other sensitivity metrics fulfilling acceptance criteria, and the analysis will be repeated with a compliant column.	The platelet count for analytical columns is an arbitrary parameter that should be established only after comprehensive evaluation of the product under analysis and the corresponding analytical method, typically during routine quality control procedures. This value is not universal across all columns; rather, it varies depending on factors such as the stationary phase, the analytical method employed, and the nature of the product being tested. When the signal-to-noise ratios at the limits of detection (LOD) and quantification (LOQ) are within acceptable ranges, and there are no discernible differences between chromatograms, there is no scientific justification for questioning column sensitivity based solely on platelet count. Therefore, the column platelet count should be regarded as an informational parameter rather than a definitive criterion for column suitability.

Table 1 Comparison of current and revised practices aligned with ICH guidelines

Current Practice	Revised practice implemented following ICH guidelines with the scientific rationale
To determine the analytical range, a linearity assessment should be conducted by preparing five calibration solutions at the lower end of the concentration range and five at the higher end. Each solution should be prepared in duplicate by using different stock solutions, yielding a total of twenty preparations. Furthermore, each sample should be injected twice into the HPLC system, resulting in forty injections overall required to complete this assessment.	The analytical method employed for validation activities is grounded in established literature, with the analytical range having been robustly defined. Previous injection runs have demonstrated that both sensitivity and linearity are satisfactory at lower concentration levels. Accordingly, the linearity assessment will entail the preparation of five calibration solutions, spanning from the limit of quantification (LOQ) to the upper end of the concentration range. A second set of solutions should be prepared using the same stock solution, with a single injection performed for each preparation. This protocol will result in a total of ten injections required to complete the linearity assessment.

Table 2 Comparison of current and revised practices aligned with ICH guidelines (contd.)

residues, transforming them into valuable products such as bioplastics precursors, animal-feed supplements, bio-fertilisers, and natural flavour and fragrance compounds. This process is carried out in closed-loop bioreactors engineered for minimal water consumption and enhanced energy efficiency. To further lower energy requirements, waste heat from nearby industrial operations is captured and used to maintain optimal fermentation temperatures, resulting in a 40

4.2 Environmental Impact

The project delivered significant environmental and economic advantages. Organic waste was successfully diverted from landfill, greatly reducing carbon emissions when compared to traditional disposal methods. The initiative also generated new employment opportunities in the green technology sector within the community. Partner companies experienced notable savings in waste management expenses, and the facility consistently produced substantial volumes of sustainable bio-based products.

Beyond these achievements, the project exemplified the potential of biotechnology to close resource loops, fostering a more circular economy and sustainable future.

- Establishing early partnerships with organisations generating waste ensures a reliable supply of feedstock.
- Prioritising energy-efficient bioreactor design has a lasting positive impact on overall sustainability.
- Maintaining transparent communication and reporting builds trust with stakeholders and strengthens community engagement.

Case Study 5: Operational Redesign for Sustainable Product Innovation

A leading household cleaning brand undertook a full redesign of its product line to eliminate single-use plastics and significantly reduce chemical waste. The company had long relied on virgin-plastic packaging and water-heavy liquid formulas, a model that was increasingly unsustainable and out of step with customer expectations for greener options.

5.1 Implementation

The organisation implemented a zero-waste product system designed to minimise material inputs, reduce lifecycle emissions, and eliminate dependence on single-use plastics. The initiative centred on developing concentrated cleaning tablets engineered to dissolve efficiently in tap water, thereby removing the need for water-based liquid formulations and significantly lowering transport mass. These tablets were paired with durable, reusable aluminium spray bottles to extend product lifespan and reduce packaging turnover. To further decrease environmental impact, the company adopted compostable refill packaging and transitioned to plant-based, non-toxic formulations that meet established safety and biodegradability criteria. In addition, a structured take-back programme was introduced to recover legacy plastic bottles, enabling material recirculation and supporting a closed-loop packaging system.

5.2 Environmental Impact

The initiative led to a substantial reduction in plastic waste, preventing millions of bottles from entering the waste stream. Transport-related emissions dropped significantly as a result of lighter, more efficient shipments, while manufacturing processes became far less water-intensive. Beyond the environmental gains, the shift toward sustainable products also strengthened customer loyalty, with noticeably higher retention among consumers who prioritise eco-friendly choices.

Case Study 6: Community Led Green Corridor Restoration Programme

A semi urban community facing declining biodiversity and increasing surface water flooding initiated a collaborative environmental programme to restore degraded green spaces. Years of soil compaction, litter accumulation, and loss of native vegetation had reduced habitat quality and weakened the area's natural resilience. Residents, local schools, and the municipal council recognised the need for a coordinated approach to revitalise the landscape and strengthen environmental stewardship at a neighbourhood level.

6.1 Implementation

The programme established a community led working group responsible for planning and delivering restoration activities across a network of public footpaths, small woodlands, and roadside verges. The initiative focused on reintroducing native plant species, improving soil structure, and enhancing ecological connectivity between fragmented habitats. Volunteers received training in habitat management, including invasive species removal, soil aeration techniques, and pollinator friendly planting. To support long term sustainability, the project introduced rain garden installations to manage storm water runoff and reduce localised flooding. Schools participated through citizen science monitoring, collecting data on pollinator presence, soil moisture, and plant growth. Local businesses contributed materials and sponsorship, reinforcing cross sector engagement. A digital reporting platform was created to track progress, share ecological data, and coordinate volunteer activities.

6.2 Environmental Impact

The programme delivered measurable improvements in ecological health and community engagement. Native vegetation cover increased across the restored areas, creating improved habitat conditions for pollinators, small mammals, and bird species. Soil quality and water infiltration rates improved, reducing the frequency of surface water pooling after heavy rainfall. The enhanced green corridors strengthened biodiversity connectivity, enabling species movement between previously isolated patches of habitat.

Beyond environmental outcomes, the initiative fostered a strong sense of community ownership. Participation grew steadily as residents observed visible improvements in local green spaces, and schools integrated the project into their environmental curriculum. The programme demonstrated how coordinated, community driven action can deliver meaningful ecological benefits while strengthening social cohesion and environmental awareness.

Green Fingertips – About this Campaign

Recently I gained a Green Ambassador status through a programme led by the Royal Society of Chemistry (RSC). The Royal Society of Chemistry(RSC) has played a significant role in strengthening my career development, expanding my technical expertise, and connecting me with leaders and experts across the chemical sciences. Through the RSC's continuous updates on emerging technologies and advances in green chemistry, I have gained a broader and more forward-looking perspective on sustainable laboratory practice.

The RSC has also encouraged me to engage more deeply with sustainability beyond the bench. The insights I have gained from participating in RSC programs reinforce a simple principle: meaningful change begins with what each of us can do in our own laboratories. By adopting smarter technologies and more sustainable workflows, we can collectively build greener labs that deliver high quality, stakeholder focused scientific outcomes while reducing environmental impact.

As part of this work, I am leading a Green campaign called "Green Fingertips" that adapts Green Chemistry concept to everyday life. The campaign highlight simple, everyday actions we can take to save energy, live more sustainably, and protect the planet for future generations. Often, all it takes is looking at things from a different angle. Small steps can create big change, especially when we act together. The campaign focus 3 areas for green activities home, general public/work and scientific work.

To support this initiative, I engaged with the broader community in general public, experts and leaders across industry, academia, local government authorities in UK through active networking and collaboration aiming to build a common platform, to raise awareness, influence laboratory culture, and encourage more sustainable day-to-day decision-making. This campaign simply promoting my contribution to the broader community for green activities.

These efforts also focus on knowledge sharing and fostering positive change in laboratory practices through continued engagement with subject-matter experts and community stakeholders. The objective is to establish a unified platform that facilitates the dissemination of knowledge, fosters positive changes in laboratory practices, and promotes the adoption of more sustainable habits in day-to-day work. This campaign serves as a tangible demonstration of my commitment to supporting green activities within the wider community. By working collectively, we can effect meaningful change through incremental actions, underscoring the principle that small steps, taken together, yield significant impact.